SALIENT LATITUDINAL GEOTECTONIC ZONES IN CHINA WITH NOTES ON THE RELATED MAGNETO-GRAVITY ANOMALIES

With 9 figures

by

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SUMMARY

In recent years geological and geophysical explorations revealed in China at least three major tectonic zones of E-W trend, as follows:

1. The Inshan zone between the latitudes 40° and 43° N, as a boundary between North China Plain and the Mongolian Plateau.

2. The Tsinling zone between the latitudes 34° and 35° N as a natural divide between North and South China, which deflecting underneath the North China Plain, reappears on the eastern side of Yellow Sea in Japan.

3. The Nanling zone between 23° and 26° N latitudes is separating the Yangtze drainage system from that of the East, North, West, and Red Rivers.

All these zones have undergone mighty North-South compressions. Some parts of them are covered by younger beds, and traversed by faults.

The zones were already existing in Sinian times, but in places they were thrown apart in Mesozoic times, or later.

The existence of these zones, where they are sunken, was discovered by magnetic and gravimetric surveys. The isogams run mainly parallel to these structures.

Such geotectonic zones appearing in certain definite latitudes occur not only in China, but in many parts of the world. The author concludes, that they are of planetary origin, and connected with the present axis of rotation of the Earth. He refers to the tidal analyses of G. H. Darwin, then the researches of J. S. Lee, B. L. Lethchkov, and M. V. Stowas. The latter's theory gives account of the presence of some latitudinal zones, e. g., the Tsinling-zone.

J. S. Lee conceives that changes in the Earth's rotational speed may be caused by the uplifting and sinking of the various portions of the continents and oceans. As the Earth's internal portions are more sturdy to comply with the changed rotational speed than the crust, the superficial layers would tend to shift towards lower latitudes. Moreover, his theory offers an explanation for the occurrence of longitudinal tectonic zones, like the Cordilleran geosyncline and the longitudinal mountain ranges of western China, continuing southward to form the Indonesian arc. The same way, along the eastern margins of the continents were brought about the tensional zones, like the ocean deeps along the eastern Asiatic continent.

The existence of east-west geotectonic zones in China and elsewhere in Eastern Asia [1, 2] at definite intervals of latitude was first recognized by Professor J. S. Lee in the early twenties of the present century. Since that time powerful structural disturbances of different geological ages along the several latitudes have been steadily brought to light from place to place [3] not only in other continents but also in parts of the great ocean basins.

In recent years extensive geological and geophysical explorations in numerous mountainous areas in China and in some of the adjoining plains have further revealed the subterranean existence of these tectonic zones. They are here and there interfered with by tectonic zones of other trend and are often covered by subsequent sediments.

It is now well known that there are in China at least three major tectonic zones [4, 5] of east-west trend (Fig. 1). Enumerating from north to south, they are as follows:

(1) The Inshan zone spreads between the latitudes 40° and 43° N, more intensely developed in latitudes 41°–42°. It marks the boundary between the North China Plain and the Mongolian Plateau. To the west it is more or less in

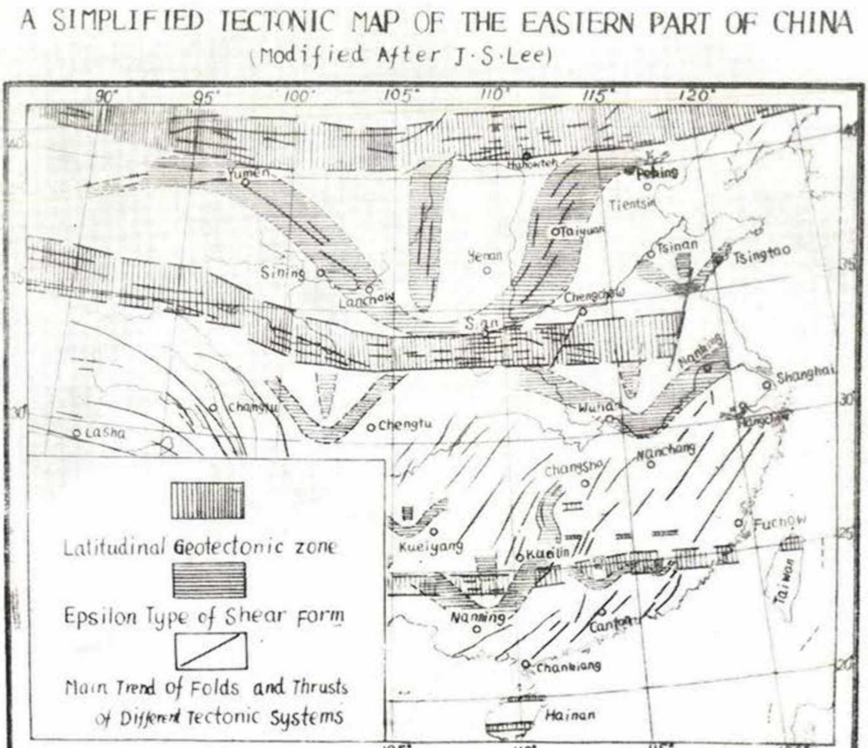

Fig. 1. Sketch map showing the distribution of the east-west geotectonic zones in China

line with the Tienshan Range, though the latter is somewhat deflected to the north. To the east it transects the Sungliao Plain and the Changpeishan Range.

(2) The Tsinling zone constitutes the natural divide between North and South China. This zone is spread between the latitudes 33° and 36° N more powerfully compressed in latitudes 34°–35° and somewhat deflected to the north in its western continuation, the Kuenlun Range. Towards the east it dives underneath the North China Plain but reappears on the eastern side of Yellow Sea in Japan.

(3) The Nanling zone stretches along latitudes 23°–26° N, roughly forming the divide of the drainage system of the Yangtze on the one hand and that of the East, North, West and Red Rivers on the other.

Of these three zones the Inshan and the Tsinling are far more prominent than the Nanling both in morphological and tectonic senses, the latter, though does not persistently trend east-west in its superficial structure, but the emplacement of a linear series of granite along this zone in a general east-west direction proving the deep-seated nature of this zone.

There is one common tectonic feature about all these zones, that is, they all have undergone mighty north-south compression more than once resulting in the formation of highly compressed folds, sometimes recumbent, and overthrusts with a general east-west strike.

The Inshan zone consist of folds of grand scale (Fig. 2.).

Its subsided eastern part runs across the Sungliao Plain forming the divide between the Sunghua-Kiang in the north and the Liaoho in the south. It is known as the Tiehling anticline, situated in latitude about 32° N, north of Mukden. It stretches east-west for hundreds of kilometres. Archaean gneiss and schist occupy a wide area in its axial part. These ancient rocks are unconformably overlain by a great thickness of Palaeozoic strata ranging from the Sinian to Permo-Carboniferous. Silurian and Devonian are absent on the southern side of the said anticline. On its southern side there occurs the Yenshan depression [6], likewise running east-west along the border between the Autonomous Inner Mongolian Region and the Hopei Province. Circumstantial evidence indicates that the Tiehling anticline has been uplifted in post-Sinian times probably by the Luliang movement.

In the area of northern Hopei [7, 8] of the Yenshan area and further west in the Tachingshan Range (Fig. 3), the Palaeozoic sediments and the Jurassic coal-bearing series are all involved in asymmetrical or overturned folds of subordinate magnitude [9, 10]. Their axes all trend east-west. They are best developed in the axial part of a synclinorium. Schuppen structures and rumping faults are sometimes observable. Such a state of intense diastrophism is always confined to a number of narrow belts, e. g., one (Fig. 4) of these belts lies about latitude 40° 30′ N in the northermost part of Hopei Province. The other belt runs along latitude 41° 40′ N on the southern side of Tachingshan anticline. Within this belt Jurassic coal-bearing basins of east-west trend are scattered here and there. They vary in size. The largest attains the length of 60 kilometres. On the border of these basins, such as the Shihguaitze coalfield (Fig. 5) northwest of Huhohaoteh city, a sequence of Palaeozoic strata and pre-Sinian metamorphics is overturned to the north. The intensity of deformation is how-

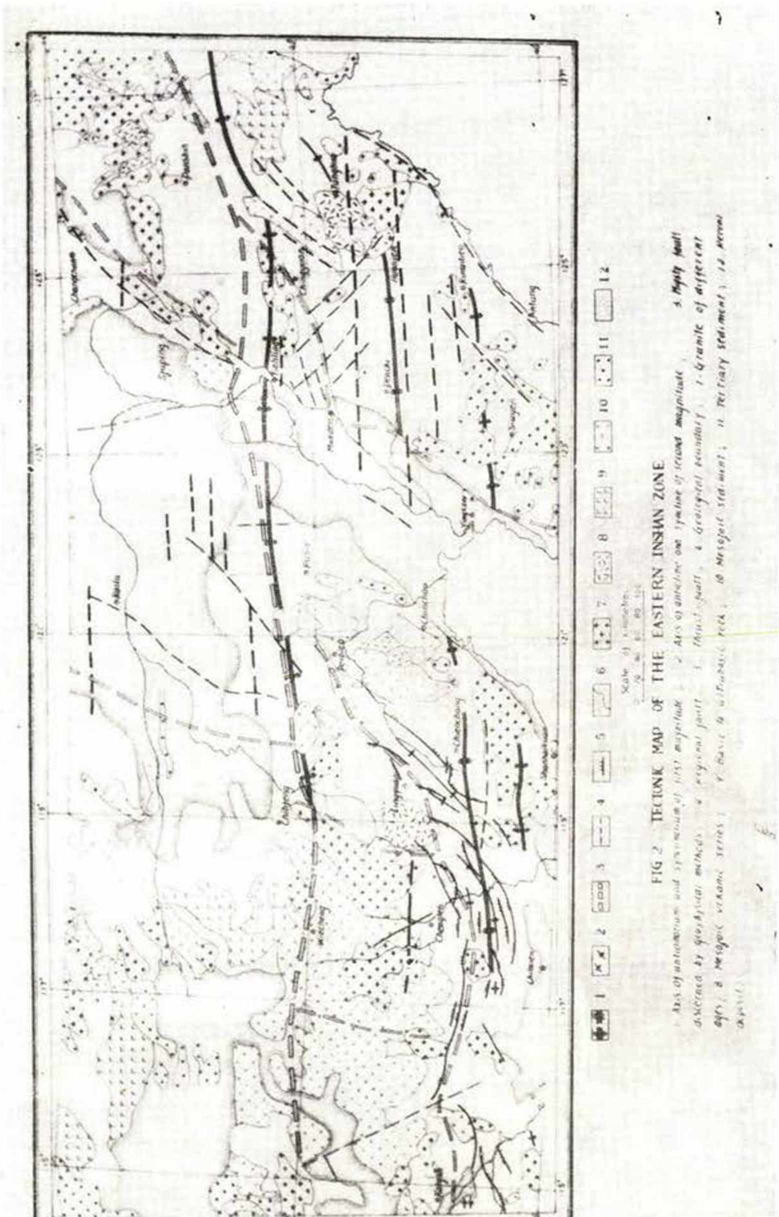

Fig. 2. Tectonic map of the eastern part of the Inshan Zone

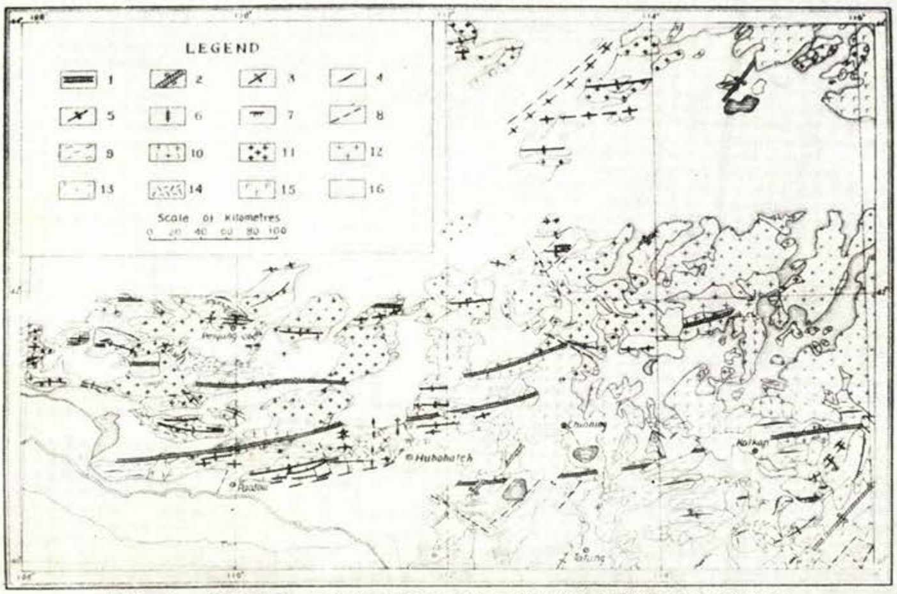

FIG. 3 TECTONIC MAP OF THE TACHINGSHAN AND PEIYUNG-OBE REGIONS

1. East west fold zone; 2. Northeast trending fold of first magnitude; 3. Anticline of second magnitude; 4. Doubly pitching anticline; 5. Syncline of second magnitude; 6. Compressed zone; 7. Thrust fault; 8. Fault suspected; 9. Archaean gneiss; 10. Pre-Sinian gneissic granite; 11. Palaeozoic granite; 12. Mesozoic granite; 13. Jurassic coal-bering series; 14. Cretaceous tuff-conglomerate; 15. Tertiary to Quarternary Basalt; 16. Cenozoic sediment.

Fig. 3. Tectonic map of the Tachingshan and Peiyung-Obe region.

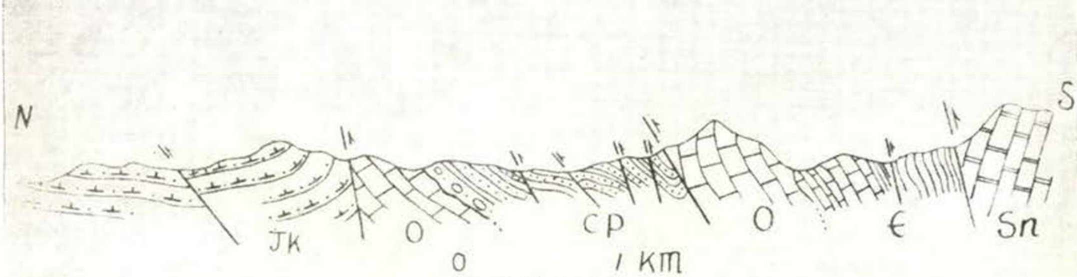

Fig. 4. Section across the Sinlung coal basin of northern Hopei, showing the east-west folds and thrusts.

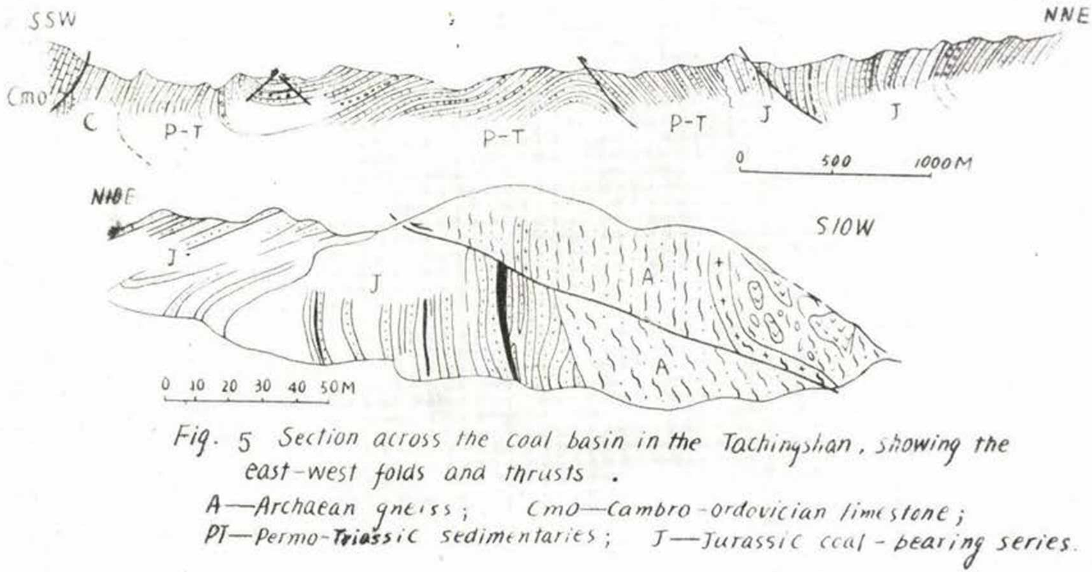

Fig. 5. Section across the coal basins showing east-west folds and thrusts in the Tachingshan region ever ostensibly decreasing towards the north. On the northern border of the basin only undulation of the exposed strata is observed.

Still further west similar intense folding [11, 12] is recorded in Archaean, Sinian and Palaeozoic rocks, being covered from place to place by Mesozoic and sometimes even by Tertiary beds. These latter are often also thrown into gentler folds.They may agree in trend with the underlying older formations, or may be entirely discordant with older rocks. Igneous activities predominate in the Inshan Zone. Elongate large masses of batholithic granite supposed to be of Hercynian age, occur in the axial part of some of the anticlines. Mesozoic intrusions appear, however, occurring in a scattered manner, but towards the east of Kalgan, these later intrusions appear to be more widespread. Bodies of ultrabasic rocks mainly of peridotite and dunite crop out sporadically all along this zone.

The Tsinling zone is also noted for a formidable pack of highly compressed folds [13, 14] and mighty thrusts (Fig. 6) with persistent east-west strike. They are well developed within the Tsinling Range proper which stands aloft in the southern part of Shensi Province. There, this zone comprises two great fold-groups, one is generally called the North Tsinling Anticlinorium, facing the

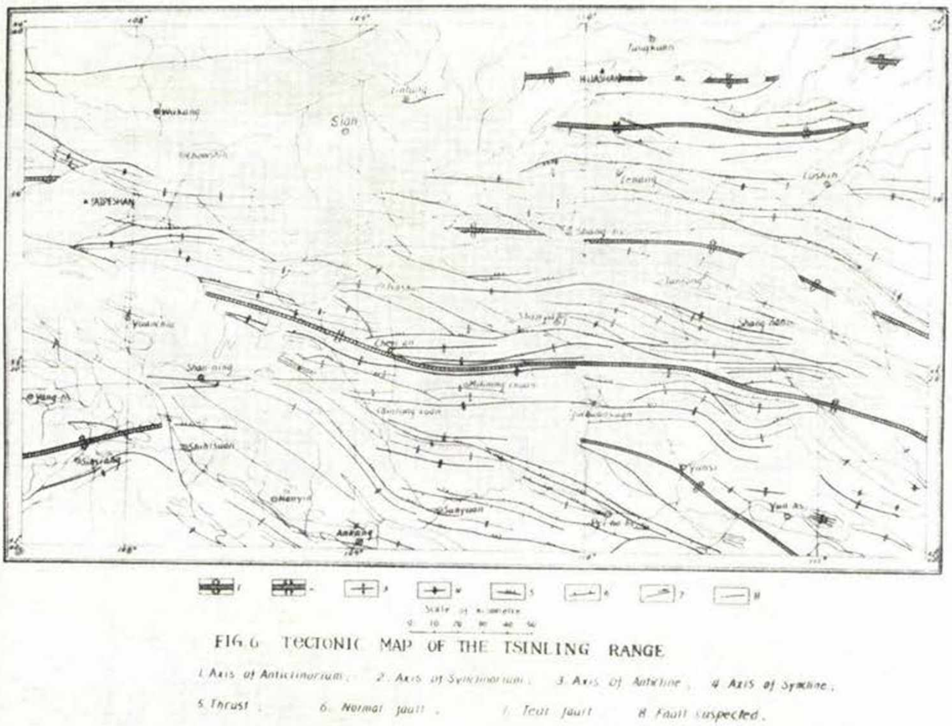

Fig. 6. Tectonic map of the Tsinling Range, southern Shensi

Shensi basin on the north with a wall-like front due to a clearcut prominent fault. The Archaean and proterozoic gneisses, schists with interbedded lenticles of marbles occupy a wide area of this remarkable anticlinorium. In this belt of ancient metamorphic rocks tight folds of subordinate magnitude are numerous, and their axial planes always dip steeply to the north. They are accompanied by some thrusts of similar trend. The other great fold-group is a wide synclinorium, well known as the South Tsinling Synclinorium. The boundary of the two great fold-groups is marked by a thrust which brings in, in the neighbourhood of Tsoshui district, the Archaean gneiss. Southward these ancient rocks thrust upon the Sinian marmorized limestones and slates.

In the South Tsinling Synclinorium a succession of Palaeozoic rocks ranging from Sinian to Permian are all disturbed by a north-south compression, forming a series of folds and faults which run almost east-west [15]. The limestones and slates from Carboniferous to Permian occupy frequently the axial part of synclines, whereas the core of anticlines is mostly composed of middle Devonian stratified rocks. They strike in general eastwest or north-west. In places the contact between different systems of Palaeozoics is often, if not all, marked by a thrust running along the same latitudes [16]. Generally a group of minor isoclinal folds (Fig. 7) occurs at certain intervals in such a manner that the strata are overturned one after another towards the axial part of a syncline from both of its limbs. These isoclinal or overturned folds are accompanied by numerous ramping faults. They usually dip at an angle somewhat larger than 60°.

Emplacements of igneous masses, largerly granites, supposedly of Hercynian age occupy a broad belt in the axial portion of some of the east-west trending folds. Mesozoic granites occur in most cases as small elongate bodies. Outcrops of a few basic to ultrabasic rocks have been observed in recent times.

Going westward from the main Tsinling Range, the east-west geotectonic zone stretches to the Kuenlun Mountains deflecting gradually somewhat to

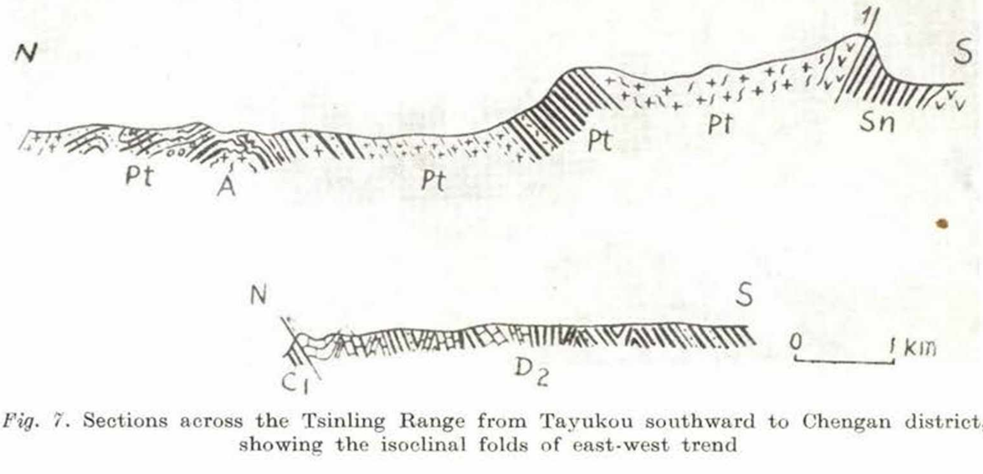

Fig. 7. Sections across the Tsinling Range from Tayukou southward to Chengan district, showing the isoclinal folds of east-west trend

the north, to the latitudes 34° – 36° N. There, folds of Palaeozoic and Mesozoic strata together with some elongated granitic intrusions all run nearly east-west. The upper Devonian limestones and a series of Permo-Carboniferous sediments are observed to have thrust northward upon the Cenozoic formations in the southern border [17] of Tsaidam Basin.

From the main Tsinling Range eastward, the east-west belt of strong folding [18] continues to extend to the districts of Chengchow, Nanyang and Hsiangyang. A line drawn to link the capital of these three districts is a line along which the said tectonic belt is suddenly intercepted as it approaches the great plain spreading out from the eastern extremity of the Sungshan anticline. Nevertheless, traces of similar structural elements are now and then brought to notice along the same latitudes in this extensive downwarped area and the Tapeishan region [19, 20]. This subsided eastern part of the Tsinling zone will be dealt with later in connection with the remarks on geophysical observations.

Unlike in the Inshan and Tsinling zones, the east-west tectonic elements of the Nanling zone are as a rule expressed by a number of thrusts [21, 22], some elongated domes and basins and several uplifted terrains of similar trend. They are often manifested by a series of acidic stocks and cupolas and especially by the batholithic intrusions of biotite granite. Northern Kwangtung (Fig. 8) and

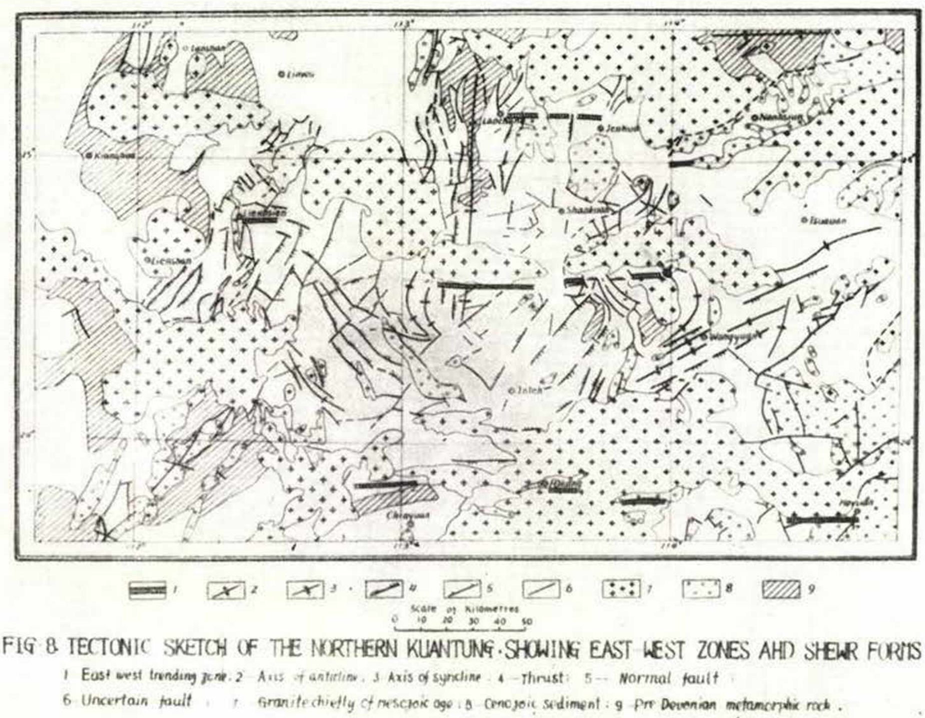

Fig. 8. Outline of tectonic features of northern Kwangtung

southern Kiangsi afford typical examples [23, 24]. There several intrusive bodies of granite extend east-west for tens of kilometres. The country rocks range from Pre-Devonian to lower Jurassic in age. These latter are disturbed by the north-south compression. Pressure joints and thrust-faults of east-west trend are rampant. In southern Kiangsi province, wellknown for tungsten deposits, the east-west large-scaled anticlines and synclines are brought into prominence by virtue of elongated granitic batholiths [25] of different ages and also by a series of elongated structural basins. The latter lies in the axial part of a syncline.

Going westward along the same latitudes, numerous folds of short axis and thrusts are observable here and there in the provinces of Hunan [26, 27, 28], Kueichow and Kwangsi (Fig. 9) [29]. In northern Yunnan [30, 31] stretches a

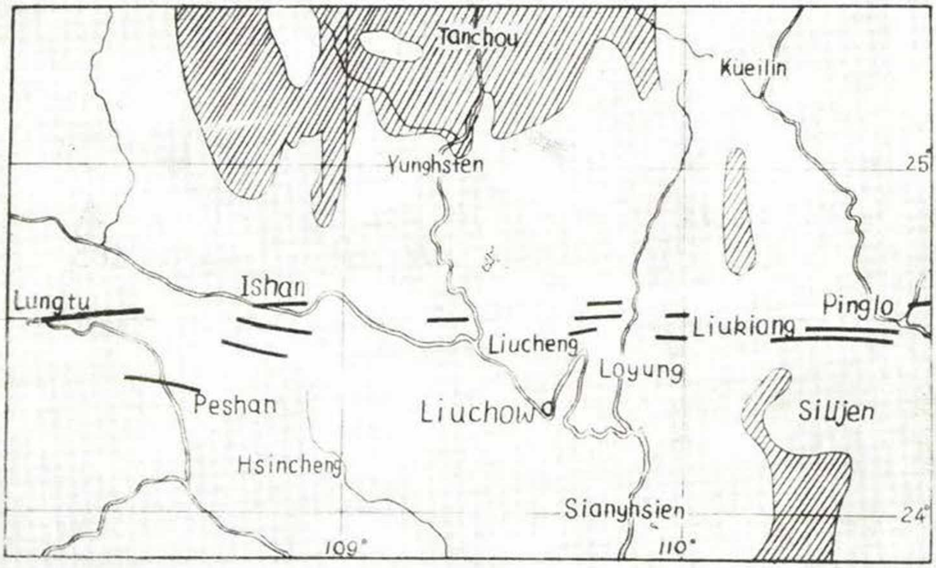

Fig. 9. Outline of the east-west folds and thrusts of northern Kwangsi.

broad and complicated anticline the core of which is chiefly constituted of pre-Sinian metamorphic rocks. The Kinshakiang suddenly bends to the west on this account. Thrust-faults are frequently present in this anticline formed by Palaeozoic and Mesozoic strata. A number of striking stratigraphical unconformities have been observed there throughout the sequence of pre-Cretaceous rocks. Structural features with east-west strike have been observed also in the vicinity of Kunming and the other districtes in a discontinuous manner. They are somewhat widely spread.

From the above-mentioned facts it appears evident that the latitudinal zones of China are highly complicated not only in specific characters but also in the history of development. Attempt has been made to look for the process of generation of these zones by palaeo-geographical methods as follows. Both the Inshan and Tsinling zones were already in existence at least in a rudimentary east-west trend early in Sinian times due to the Luliang movements. Hercynian movements undoubtedly played a part in the development of these two belts of disturbance. They began to take shape through the Yenshan movements of Mesozoic age. There is evidence to show that the Nanling tectonic zone came into being mainly in Mesozoic times, though its western part was possibly uplifted in an embryonic form by the Luliang movements. That these three tectonic zones have undergone regeneration in post-Cretaceous times is supported by certain observational facts.

As regards the inter-relation between these zones and the relation between these and the other structural systems which came to interfere with them since Mesozoic times, it may be said that the east-west zones have been in places thrown apart or even transected by a number of distorsional or vortex structures of different types and sizes and also by numerous north-north-east trending thrust and folds. In most cases, the latitudinal zones are apparently dislodged by the epsilon type of tectonic systems. They occur in mutual adaptation and sometimes penetrate each other.

In complicated tectonic regions and plains where the east-west zones run across, it is often of paramount importance to resort to geophysical investigation in order to detect the existence of the east-west tectonic zones. In China, until now, aeromagnetic works have been fairly extensively carried out, while gravity measurements are restricted only to definite areas. It hardly needs to be remarked that the isomagnetic lines and the magnetic anomalies are closely related to each other, both being determined by the distribution of different rock types possessing or underwent different degree of magnetization. Since different granitic rocks and basic and ultrabasic rocks of different ages usually occur in the east-west tectonic zones, and since the amount of magnetic minerals present in sedimentary rocks as a rule varies, aeromagnetic investigation often proves to be a method more rapid and more efficacious than any other in detecting the existence of the east-west tectonic zones.

For similar reasons gravity survey also turns out to be equally useful, since the more outstanding structures of the basement rocks under the plains are often revealed by various density of the rocks involved in the structures. Needless to say, in the case of gravity measurement, latitudinal corrections must be made.

Geophysical surveys [32] along the Tiehling anticline and the adjacent Yenshan syncline on the south has established the fact that the isanomals both in the magnetic and gravitational fields run essentially parallel to each other. It is further shown that in magnetic field three belts are discernible. The northern belt is more or less wide-spread, the anomalous value ranges from -250 to $+250\ \gamma$. The middle belt, situated in latitudes $40°\ 20' - 41°\ 20'$, runs almost strictly east-west, and can be subdivided into a number of sub-zones of positive and negative anomalies. The positive sub-zones vary in their magnetic anomalous values from 500 to 1000 γ, at points even rise to 4000 γ. In the negative sub-zones the values $-250\ \gamma$ to $+250\ \gamma$ are recorded. The southern belt, situated in latitude about 40° N., also shows anomalous values ranging from $-250\ \gamma$ to $+\ 250\ \gamma$. Gravitational anomalies in this area are also distributed in three sub-zones, all running east-west: in the northern subzone -85 to -135 mgl, in the middle zone -50 to -100 mgl, in the northern sub-zone $+10$ to $+20$ mgl. The most conspicuous anomalous zone lies in latitude 41° N.

Gravity survey shows that in the vast plain of northern China, there exist east-west trending depressions and swells in the eastern part of Honan province, for example, the Kaifeng depression and the Tungshu swell. These are situated in the neighbourhood of latitude 34° 20′ which agrees with the latitudinal position of the main Tsinling Range. This anomalous gravity zone continues to run farther east, coinciding with the east-west structural zone between Hsuchow and Yihsien.

On the northern side of the Tapei Range and in the plain of the Huai River latitudes 32°–33°, both the isogams in the magnetic field and isanomals in the gravitational field run nearly parallel to each other, all trending approximately east-west, disclosing subterranean existence of an east-west zone of dense rocks with marked magnetic property.

In the Nanling Range, the superficial structure is highly complex as already alluded to. Geophysical investigation shows, however, that there exists underneath the sedimentary cover a persistent east-west zone of granite together with associated metamorphics. A prominent example occurs in northern Kwantung where an elongate porphyritic granite zone extends both westward and eastward for a considerable distance. Towards the east it reaches the Hoyuan basin, in the north-eastern part of Kwantung. In the basin itself, though flat on the surface, gravity anomalies have been encountered with a north-south gradient amounting to 1.5–2 mgl/km, when latitudinal correction is made. It means that under the cover of young sediments, denser rocks form a buried hill trending east-west. Similar examples are also found in northeastern Kwantung (about latitudes 23° 40′–24°) where magnetic disturbance is particularly pronounced, valuing 100–200 γ, and in the granitic region of the southern part of Fukien province, where the iso-magnetic lines and the transitional line along which the region with positive anomalies changes into negative anomalies run east-west. A significant example is found to the north of Lungyen, southern Fukien.

The fact of far-reaching significance is that such prominent geotectonic zones, as are mentioned here, do not only occur in China but in many parts of the world in the continents as well as in ocean basins. Although they apparently differ in their tectonic nature, and perhaps rose or have become active in different geological times, they generally appear in certain definite latitudes. Some of them agree in their latitudinal position with those which we have dealt with here. It is therefore admissible to conclude that prominent latitudinal geotectonic zones, whatever their real nature, are of planetary origin, and have had a long history in the geological past.

This conclusion leads at once to the inference which is equally far-reaching in an attempt to elucidate the history of the dynamic behaviour of our Earth. Since these large-scaled complex geotectonic zones persist to run east-west, it is further deducible that their origin might, in some way, be connected with the present axis of rotation of the Earth.

From harmonic analysis G. H. Darwin first pointed out the possible existence of deformational zones on the Earth's surface parallel to the equator.

He called them harmonic mountain ranges [33]. In Darwin's time nothing however is known of any such para-equatorial ranges or of structural zones. About three decades ago Prof. J. S. Lee [34] and Prof. B. L. Lithchkov [35] independently and almost simultaneously called attention to the presence of such zones from the geotectonic point of view. These authors traced the origin of these structural zones to the effect of Earth's rotation, and in some cases coupled with tidal attraction. More recently Dr. M. V. Stowas [36] elaborated mathematical analyses with a view to unfolding the reason why large-scaled geotectonic zones should be located in certain definite latitudes. It is of interest that Stowas' theory does account for the presence of some latitudinal zones, notably those corresponding to our Tsinling. There remain, however, others which still require explanation with the same precision as attained by Stowas.

In this connexion a few words may be said of the hypothesis offered by Prof. J. S. Lee [37]. He stresses the change of the rate of the Earth's rotation around its own axis throughout geological times. Lee conceives that such changes of the Earth's rotational speed may be caused by the uplifting and sinking of the various portions of the continents and the oceans or by the contraction of the entire Earth due to the change of the Earth's thermal conditions. Gravitational differentiation of the materials within the Earth and the tidal pull on the superficial layers of the Earth must be, according to him, also be taken into account.

When the rate of the Earth's rotation increases, the ellipticity also increases, but the rigidity of the internal portions of the Earth is conceivably greater. Hence the internal portions are more sturdy to comply with the changed rotational speed than the crust. Under those circumstances the superficial layer of the Earth would tend to shift towards the lower latitudes in order to accomodate the required ellipticity. The results are: along those belts where such thrust movements are strong and uniform, they give rise to the formation of the east-west tectonic zone; whereas along those belts where such movements are not uniform and unbalanced, they give rise to the formation of a variety of horizontal shear [38] and vortex structural types [39]. As a corollary to follow the above reasoning we can readily offer an explanation for the occurrence of longitudinal tectonic zones [40].

If certain portions of the Earth's crust, as in the case of some continents, cannot follow up the increasing rate of rotation, they will lag behind those neighbouring portions. Consequently, along their western margins and along certain longitudinal lines in the interior of the continents where the landmass on their eastern side fails to keep pace with the western as the Earth spins faster, there will arise longitudinal compressional zones. Spectacular examples of such zones are the Cordilleran geosyncline and the lofty longitudinal mountain ranges of western China continuing southward to form the Indonesian arc. Along the eastern margins of the continents where they fail to keep pace with the ocean floor in their eastward march, there may be brought about tensional zones. Those ocean deeps occurring along the eastern Asiatic continent are presumably attributable of this origin.

When the Earth's rate of rotation decreases the entire tendency of the crustal movement will proceed in the opposite manner.

Numerous other hypotheses have been proposed by geologists and geophysicists from time to time to account for the origin of geotectonic movements. None can however claim to be founded on substantial tectonic grounds unless an adequate account is given as to why there exist on planetary scale such extensive and deep-seated tectonic zones as those which we have dealt with here.

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